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# Volumetric Determination Of Carbon by Combustion With Sodium Peroxide

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# VOLUMETRIC DETERMINATION OF CARBON BY COMBUSTION WITH SODIUM PEROXIDE

...BY...

Charles Edwards

THESIS

FOR THE DEGREE OF BACHELOR OF SCIENCE
IN CHEMISTRY

COLLEGE OF SCIENCE
UNIVERSITY OF ILLINOIS

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May 27 1904

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Charles Edwards.

ENTITLED Volumetric Determination of Carbon by Combustion with Sodium-peroxide

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science

A. W. Parr

HEAD OF DEPARTMENT OF Applied Chemistry.

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Carbon is one of the most widely distributed elements in nature, so the question of its determination by some method which is short, simple and accurate, is one of great importance to the chemical world.

In the latter part of the eighteenth century Lavoiser (1) attempted to analyse organic compounds. He knew that carbon, when burned, yielded carbon dioxide, and he had established with some precision, the relative proportions in which carbon and oxygen enter into its composition.

From the work of Cavendish and from his own experiments, Lavoisier knew the relative proportions in which hydrogen and oxygen unite to form water; from these facts he endeavored to ascertain the proportions in which hydrogen, oxygen and carbon are present in alcohol and oil. He burned weighed quantities of them in small lamps placed under recievers standing over mercury, to which measured volumes of oxygen could be added if necessary during the process. He measured the carbon dioxide formed and the volume of air remaining, and endeavored to calculate from this data, the composition of the substance burned. But owing to the fact that his knowledge of the density of the gases concerned, was not sufficiently accurate, the results of his experiments had no permanent value.

From the time of his death until Liebig entered the field of chemistry nothing of value was learned along the line of organic analyis. His work was done at Giessen during the second quarter of the last century. The method of organic analysis which he devised consists in completely oxidizing the substance to be analysed and then collecting the carbon dioxide and water formed. The method will be described later in this work.

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At persent there are many methods and various forms of apparatus in use for the estimation of carbon in different substances. They may be classified as follows:- gravimetric, volumetric, absorption, combustion and by the color method as used in the analysis of iron and steel. There are included in these different classes many methods and modifications.

There are difficulties to be encountered in all these methods; opportunities for error continually arise; some are inaccurate and others are long and laborious, requiring much time and a skillful operator to manipulate in order to obtain good results. This is especially so in the case of Liebig's (2) combustion method. It is one which involves complex apparatus and various materials, thus increasing the liability to error on the part of an unskilled operator.

This method is one of the standard methods in use at the present time for the determination of carbon, and a large amount of work has been done to bring it to perfection. There are several modifications in use adapting it to the analysis of different compounds; these consist chiefly in the chemicals used.

The essential features of the method are the combustion of the substance in a medium of copper oxide in a current of oxygen within a combustion tube heated to redness; and the absorption of evolved gases in sulphuric acid and potassium hydroxide.

If other gases, such as sulphur dioxide are formed and are absorbed in either the sulphuric acid or potassium hydroxide, the determination will be inaccurate. This absorption of other gases is one of the greatest difficulties encountered in using this method, and to avoid this it is necessary to absorb all gases except the

carbon dioxide and water vapor.

It is also very necessary to have a complete combustion of the material used so as to obtain all the carbon in the form of carbon dioxide. The method is very complicated and takes considerable time; the results obtained are very accurate providing the manipulation has been careful. It is used almost entirely for the determination of carbon in organic matter, soils, coals, etc.

Several gravimetric methods are in use for carbon determination in metallic carbonates. The salt is weighed and ignited in a platinum crucible until the weight of the residue remains constant. The carbon as carbon dioxide is thereby liberated and the difference in weight affords a means for its determination. The results are accurate, more so for anhydrous carbonates than for the hydrated salts; for these a slight modification is intruduced. The substance is ignited in a bulb tube, through which dried air, or, in the presence of oxidisable substances, carbon dioxide is transmitted, and this tube is connected to a weighed calcium chloride tube. The loss of weight of the tube gives the amount of carbon dioxide and water liberated, and the increase in weight of the calcium chloride tube gives the weight of water; the difference being the weight of carbon dioxide. (3).

Carbon dioxide can also be determined in salts by treating with acids and finding the difference in weight.(4). This is done by means of alkalimeters, and instrument of which there are several different types in use, such as the Mohr's, Thoerner's, Geissler's, Schroetter's and many others. The principle involved is the treatment of the compound in the flask with acid and the liberation of carbon dioxide, the amount of which is determined by difference

in weight.

When treating a salt in this manner there is a possibilty of the escaping gas taking some moisture; this is prevented in some of the latter forms of the alkalimeter, by passing the gas through the sulphuric acid receptacle and thereby removing the water vapor.

The amount of carbon dioxide given off may also be determined by collecting it in a weighed set of potash bulbs. (5)

The absorption method as used in gas analysis, consists of passing a known volume of gas into a potash pipette and then withdrawing the gas, the difference in the volumes being the carbon dioxide.(6) Where carbon occurs in the form of hydrocarbons, as in illuminating gases, the gas is passed into alcohol and then into fuming sulphuric acid which absorbs the lighter and heavier hydrocarbons respectively. The difference of volumes gives the amount of hydrocarbons present. In case the composition of the hydrocarbon is unknown, th e gas is mixed with oxygen and ignited in an explosion pipette. Carbon dioxide is formed and can be determined by absorption in the potash pipette. (7)

Where carbon dioxide is present in small quantities as in atmospheric air it is determined by Hesse's (8) method. This consists in taking a known volume of air and bringing it in contact with a certain amount of standardized barium hydrate. The solution is liberated with oxalic acid which gives the amount of unchanged hydrate. The carbon dioxide is then calculated from the amount of barium carbonate formed.

The several methods for determination of carbon in iron and steel may be divided as follows:- (a) The direct treatment of the drillings without previous separation of the iron; (b) Removal of

the iron by volatilization and the subsequent combustion of carbon; (c) Solution of the iron and combustion or weighing of the residue. Under these various headings are included several methods slightly modified from each other. (9)

It seem that from extensive experimental work the most accurate of all the methods included above, is that in which the drillings are dissolved in cupric potassium chloride, and the residue burned in oxygen gas. (10)

Geo. A. Seward (11) has designed an apparatus for the determination of carbon in electric furnace products, such as ferro-chrome, etc. A perfect combustion is obtained by igniting the substance in a sodium peroxide mixture by means of an electric spark.

Previous to this the best method for the determination of carbon in ferro-chrome, necessitated the use of the combustion furnace. The fusion with the resulting oxidation of the metal as well as the carbon is complete in about one minute.

The mass formed by the fusion is treated with sulphuric acid, and the carbon dioxide liberated is collected in potash bulbs. A stream of oxygen is passed through the apparatus so as to remove all the carbon dioxide.

As this thesis treats of a volumetric method for carbon determination, by measuring the volume of carbon dioxide direct, it will be necessary to give a somewhat detailed account of some of the methods in use.

The earlist form of apparatus used for this method is that of Dr. Scheibler, (12). It is adapted for the estimation of carbon dioxide in native carbonates, as well as in artificial products; it was originally contrived for use in the analysis of bone-black used

in sugar refining.

The principle of the apparatus is simply this, that the quantity of carbon dioxide in calcium carbonate can be used as a measure of the quantity of the salt itself, and instead of determining the quantity of gas by weight, this apparatus admits of its estimation by volume. By this means it is possible to perform in a few minutes, operations which would otherwise take hours, and furthermore it does not require a skilled chemist to operate.

The substance is treated with hydrochloric acid in the bottle. (A). The carbon dioxide thus liberated is passed into a rubber bag contained in a large(FIGURE I ) bottle (B). The pressure by the gas forces the water from (B) into a burette. The volume of water displaced is equal to the volumeof gas evolved. The temperature and pressure are then noted, and from tables (13) and (14) the weight of carbon dioxide can be found, and from it the carbon is calculated

Chas. A. Catlin (15) has devised and improvement on this apparatus. He has introduced several pipettes of varying volumes, into the system, so as to enable it to be used for measuring large volumes of gas. The other features are practically the same as in the Scheibler. (FIGURE II ).

There are some drawbacks to these apparatus and methods. All of the gas may not be evolved from the acid solution unless boiled, this would effect the temperature of the system which should be kept constant. It is also necessary to make corrections for the solubility of the gas in solution by checking with gravimetric determinations for the different materials used. The apparatus is said to be satisfactory for technical purposes, where extreme accuracy is not as necessary as rapidity.

An instrument used for the estimation of nitric acid in the form of nitric oxide is the Lunge Nitrometer. (19) It has been found extremely useful for technical gas analysis and for the rapid testing of manganese peroxide, hydrogen peroxide, bleaching powder, urea, etc.

The simplest form consists of a graduated measuring tube fitted at the top with a three-way stopcork and a glass cup or funnel, and a leveling tube.

One great advantage of this instrument is that it is adapted for the use of mercury, thus insuring more accurate measurements and enabling gases soluble in water to be examined.

By the addition of a small decomposing flask Lunge has adapted the instrument for the estimation of urea in urine by hypobromite.

If it be required to test burner gases for carbon dioxide and oxygen, the gases are aspirated into the nitrometer-tube; a potassium hydroxide solution is introduced through the cup into the measuring tube. After shaking, the percentage of carbon dioxide can be read off. Then some concentrated pyrogallic acid solution is added and the oxygen estimated. In case the analysis of gases have to be performed where reagents must be employed which act on each other, the nitrometer is combined with several of Hempel's pipettes. The instrument has also been used for many other purposes.

In order to meet the requirments for the analysis of various electrometallurgical products, more particularly the carbides of silicon and titanium, F. J. Fitzgerald and H. Loomis (16) have devised the following volumetric method. The use of sodium perozide was first suggested by W.T. Gibbs and A. Edinger (17).

The old method for determing carbon in silicon carbide used

by Moissan and Mühlhauser, was by heating the sample in a combustion tube with lead chromate. This was a very troublesome process.

The great difficulty in obtaining a complete combustion of carbon, necessitated the reduction of the sample to the finest powder. A small sample of the carbide is mixed with about a gram of calcined magnesia, and a quantity of fresh sodium peroxide, equal to ten or fifteen times the weight of carbide taken. The peroxide must be weighed in oder to make a correction for the carbon dioxide present in it. The magnesia keeps the molten caustic soda formed by the reaction, in a porous and readily soluble condition. These substances are thoroughly mixed in a nickel crucible, a hydrogen flame is then applied to the bottom and sides of the crucible. The reaction generally starts in 20-30 seconds and is complete in 10 more. The contents of the crucible are dissolved in hot water, boiled for a few minutes and then transfered to a flask of a Knorr's apparatus, or the carbon dioxide may be determined by any suitable method.

The question may be raised whether the method does not offer too much opportunity for the peroxide to absorb carbon dioxide from the air, thus introducing a variable error. This was investigated and it was found that the error was inappreciable. On the whole it is claimed that the method has proved very satisfactory for the work for which it was devised.

In the wet combustion , by dissolving in acids, copper sulphate or a mixture of sulphuric and chromic acids, of iron containing carbon, a part of the carbon is always set free in the form of hydrocarbons. To prevent this Hempel (18) found that by treating iron with chromic and sulphuric acids in the presence of mercury,

all the carbon is set free in the form of carbon dioxide, thus avoiding the above mentioned error.

A small sample of the iron with a few grams of mercury, is dissolved under diminished pressure in a mixture of sulphuric and chromic acids and water. The mixture of gasses consisting of air, carbon dioxide and oxygen, that is set free is then measured, and the carbon dioxide is volumetrically determined by absorption in potassium hydroxide.

## PREVIOUS INVESTIGATIONS.

In 1896 while experimenting with the Lewis Thompson calorimeter, Prof. S.W. Parr (20) tried the effect of a small amount of sodium peroxide in the mixture of potassium chlorate and potassium nitrate, then used for determining the calorfic values of various substances, and found that a more complete combustion was effected. From this work there arose the possibility of using the peroxide alone and utilizing its absorptive power for carbon dioxide. The result of this work were the Parr calorimeter, the bomb of which has been used to make the combustions in the experimental part of this thesis, and the method and apparatus for the determination of carbon dioxide in the residue.

In some cases the combustion was not perfect, as in the case of sugar carbon, napthalene and anthracite coals, etc., so an attempt was made to find some accelerator that would aid in accomplishing a more complete combustion. It is with this that a large part of this work is devoted.

## OUTLINE AND OBJECT OF THIS INVESTIGATION.

### I.

A study of various mixtures in regard to their effect on increasing the combustion of compounds.

II.

The method and apparatus for determining carbon in various substances.

III.

Improvement of method, bomb and apparatus in order to overcome several causes of error.

IV.

Determination of carbon in soils, coals and several miscellaneous compounds.

## INVESTIGATIONS.

The first experiments in this thesis were made with the object of obtaining a mixture which would give a complete combustion of the compound to be analyzed. Mixtures composed of sodium peroxide, with one or more of the following substances, sulphur, magnesium powder, magnesium oxide, lead oxide, silica, potassium salts, sodium salts and ammonium salts, and the substance to be analyzed, were made in varying proportions.

In the preliminary work these were placed in a small iron crucible, and a red hot wire dropped in them to see if an ignition would be effected. In case no reaction took place after several repetitions, the proportions of the substances in the mixture were varied. This was done until it was found that no reaction would take place with the substances in question, or until a reaction did occur. When the right proportions were found, the mixture was placed in the bomb of a Parr calorimeter. Ignition was effected by dropping a hot wire through the stem of the bomb. After the combus-

III.

IV.

tion the bomb was cooled, and the mass formed by the reaction was removed; it was then dissolved in hot water. As soon as solution is effected hydrochloric acid is added until acidified. . If the substance is completely burned there will be very little, if any, residue remaining.

The first substance used was cast iron; The data and results of the experiments are given in table NO.

Some of these combustions were very good, most of the iron was completely burned. For instance, when using the following mixtures, (1) 5 grs. peroxide, 1 gr. powdered potassium persulphate and 3 grs. of finely ground cast iron; (2) 10 grs. peroxide, 3 grs. persulphate and 3 grs. of iron; (3) 10 grs. peroxide, 5 grs. iron and 2 grs. persulphate; (4) 10 grs. peroxide, 2.5 grs. iron, 1 gr. ammonium persulphate and 1.5 grs. flowers of sulphur; (5) 10 grs. peroxide, 1gr. iron, 2 grs. potassium persulphate, and 2 grs. ferromanganese, very good combustions were obtained.

Some of the residues were very difficultly soluble, as indicated in table NO.I. This fact renders them useless for rapid carbon determinations.

A few of these residues were treated in the carbon dioxide apparatus, whichwill be described later; but owing to the facts that errors were caused by variations in tempature and to several inaccuracies of the method and early form of the apparatus, the results were not concordant. This brings us to the method and apparatus used for the volumetric determinantion of carbon.

## METHOD AND APPARATUS.

The residues from the bomb are dissolved in distilled water and boiled for about five minutes to drive off any oxygen which may be

left uncombined in the mass. The solution is poured into the drop funnel (C). (See FIGURE IV.). The drop funnel (B) contains about 200 c.c. of a mixture of one part water and one part conc. sulphuric acid. The stems of these two funnels are bent so as to pass through the rubber stopper in the neck of flask (D); this flask has a capacity of about 150 c.c. To operate the apparatus the flask (D) is filled completely with acid from (B), to the zero mark at (G) of the water-jacketed burette (A). Exactly 100 c.c. of air at ordinary pressure, is drawn into the burette through the three-way cock at (G) and is then forced through the capillary tube into the flask, thus returning the acid to the receptacle (B), leaving 25-35 c.c. of acid in the flask. The stopcock at (B) is closed and that at (G) opened; the alkaline carbonate solution from (C) is admitted to the flask; this on coming into contact with the acid is decomposed and carbon dioxide liberated, which passes into the burette. When the volume of gas reaches the limit of capacity of the burette, the stopcock at (G) is closed, and the volume brought to atmospheric pressure by means of the leveling tube (E). After the reading is taken the gas is forced out in the air, thus bringing the water in the burette to the zero mark at (G). Communication is again established between the burette and the flask. More of the carbonate solution is admitted to the flask and the above operation repeated. When all of the solution is passed into the flask, the funnel (C) is washed with hot water; heat is applied to the flask thus boiling off all the carbon dioxide contained in the acid solution. The flask is then filled completely with water to the zero point at (G); the gas is measured as above.

The total volume of gas minus the 100 c.c. of air used at the

start, is the volume of carbon dioxide. The temperature indicated by the thermometer in the water surrounding the burette, and the barometer reading are taken and by refering to the carbon dioxide table (II) the weight of the carbon per c.c. of carbon dioxide is found; from it the the weight of carbon in the total volume of gas is calculated.

A correction factor for the sodium peroxide is necessary as it contains some carbon dioxide. This is obtained by dissolving a weighed amount of the peroxide in hot water and boiling for a few minutes. The solution is treated in the above apparatus and the volume of carbon dioxide determined as above. This is calculated to carbon from the table and is subtracted from the carbon value obtained in the above experiments thus giving the weight of carbon in the substance itself.

## SOILS.

Several determinations of carbon were made on a series of ten soils furnished by Mr. Pettit of the Agricultural Experiment Station of the University of Illinois.

The soils contained an insufficient amount of organic matter to complete the combustion so 0.5 gr. of flowers of sulphur was used with a two gram sample and ten grams of the peroxide. The results obtained were concordant; they also checked closely with the gravimetric results obtained at the Agricultural Experiment Laboratory by the Liebig combustion method. The data for this work is contained in table NO. III.

## IMPROVEMENT IN APPARATUS AND METHOD.

During this work on soils several difficulties arose and had to

be overcome in order to perfect the method and apparatus.

It was noticed that on making several successive determinations the temperature of the water in the water-jacket varied from one to three degrees centigrade, thus introducing a variable error. An asbestos screen was placed between the lamp and the jacketed burette, thus avoiding some of the change in temperature. This was not the entire cause for the rise in temperature. As the gases pass through the capillary tube they do not have time to cool before entering the burette, producing a variation of temperature and preventing the water from being uniform in temperature. To avoid this, the capillary tube was passed through the bottom stopper of the water-jacket then through the water, before connection was made with burette; this heated the water at the bottom and it radiated it at a uniform temperature. This change is shown in FIGURE (III).

When residues containing very much carbonate were treated in this apparatus, it was necessary to make several readings, and as this was not desirable, the volumes of the burette, water-jacket and leveling tube were increased. But for these changes the apparatus is practically the same as the original form.

In the old style of bomb as devised by S.W. Parr (21), the caps were made to screw into the ends; when using some mixtures, the material would be forced around the threads and plugging them. Another bad feature was the sudden cooling of the bomb after an ignition, thus forming a thin film of unburned substance next to the inner surface. To correct the first trouble and to bring the latter to a minimum, an outer jacket was made to cover the lower part of the bomb and having the threads on the outside of the bomb, thus eliminating the plugging of the caps. (See FIGURE ).

On making a comparison between several residues from combustions made with this bomb and those made with the first form, a great difference was found between the amounts of undecomposed material remaining.

A change was also made in the method of igniting the charge. Instead of dropping a hot wire into the mixture, it was ignited by passing an electric current through a fine iron wire connecting the electrodes. This electrolytic cap has no opening to allow the escape of any gases formed; the cap also screws on the outside of the bomb.

While using sulphur as an accelerator, the odor of sulphur dioxide was detected in the gas; is was more noticable when the amount of peroxide was reduced to less than 10 grams. As the presence of this gas would cause an increase in volume, it was necessary to find some substance which would take the place of sulphur. Powdered magnesium does this to great advantage; it not only increases the heat but does not form any volatile compound which would be decomposed by the acid and thereby increasing the volume of gas.

The charge now used for the combustion of soils consists of 1 gram magnesium, 10 grams peroxide and 2 grams of the soil; the results obtained are very satisfactory.

## COALS.

In the work on coals another feature entered the work. It was very desirable to find some mixture which would not only increase the completeness of the combustion, but have no effect on the calorfic value; thus enabling the operator to make use of the same

sample for both purposes.

Of the various mixtures used, the one consisting of the following substances, 0.2 gr. of finely powdered potassium chlorate, 0.8 gr. of potassium nitrate, 10 grs. of sodium peroxide and 0.5 gr. of coal sample, answered both purposes very well.

Some of the charges tried gave good combustions, but either raised or lowered the calorific values.

The old form of apparatus was used on the first coals, as indicated in the table NO.IV.

A series of Illinois coals were taken and the carbon determined by the usual method. Table No.V.

Since Dirtrich's carbon dioxide table and the one given in the Chemical Kalendar are not corrected for water tension and barometer readings, a new table was calculated. The gas volumes were reduced to $0^{o}$ and 760 m.m. by using the formula v. F. (h-w), where v. = volume, $F = \text{factor} = \frac{1}{760(1+.00367t)}$, (22), h = barometer reading corrected, and w = tension of aqueous vapor. The table contains all the values calculated to carbon, of 1 c.c. of carbon dioxide under conditions of temperature varying from $10^{o}$ -$30^{o}$ centigrade, and 740 m.m.-770 m.m. pressure.

Several miscellaneous compounds were analyzed for carbon. The list includes tartaric acid, oxalic acid, sugar, gasoline, carborundum, lignite, etc. The results are given in table NO.VI.

In conclusion the writer would say that the method and apparatus have proved satisfactory, especially so in the analysis of coals and soils. The rapidity and the accuracy of results obtained, also the variety of compounds analyzed seem to indicate to a wider application of the method.

# BIBLIOGRAPHY.


| | | | Page. |
|---|---|---|---|
| 1. | Justis von Liebig, His Life & Work by W.A. Shenstone | | 20 |
| 2. | Gatterman's Organic Analysis | | 98-107 |
| 3. | Fresenius Quantitative Analysis | | 407-408 |
| 4. | " " " | | 412 |
| 5. | " " " | | 413 |
| 6. | Hempel's Gas Analysis | | |
| 7. | " " " | | |
| 8. | " " " | | 337-346 |
| 9. | Blair's Iron and Steel Analysis | | |
| 10. | " " " " " | | |
| 11. | Electrochemical Industry | June 1903 | 366 |
| 12. | Sutton's Volumetric Analysis | | 86 |
| 13. | Chemical Kalender | | 188 |
| 14. | Zeitschrift fur Analytische Chemie | Vol. 4. | 141 |
| 15. | J.A.C.S. | " 15. | 614-618 |
| 16. | Electrochemical Industry | " 1. | 40 |
| 17. | Zeitschrift fur Analytische Chemie | | |
| 18. | Hempel' s Gas Analysis | | 459 |
| 19. | Sutton's Volumetric Analysis | | 479-483 |
| 20. | B.S. Thesis, U. of I. (R. N. Kofoid.) | | |
| 21. | J.A.C.S. | Vol. 26. | 294-7 |
| 22. | Wells Chemical Calculations | | |

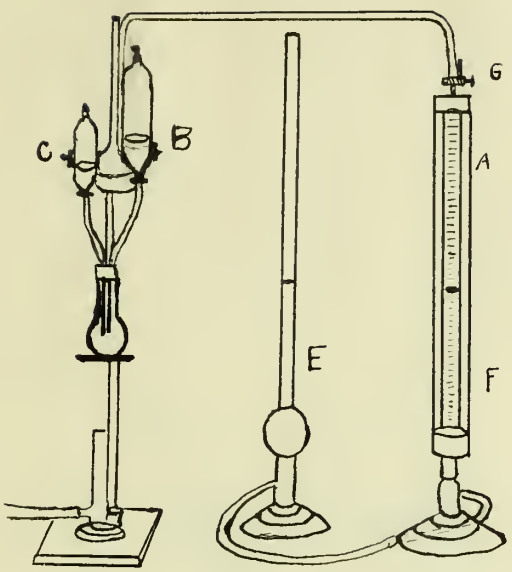


Fig. IV

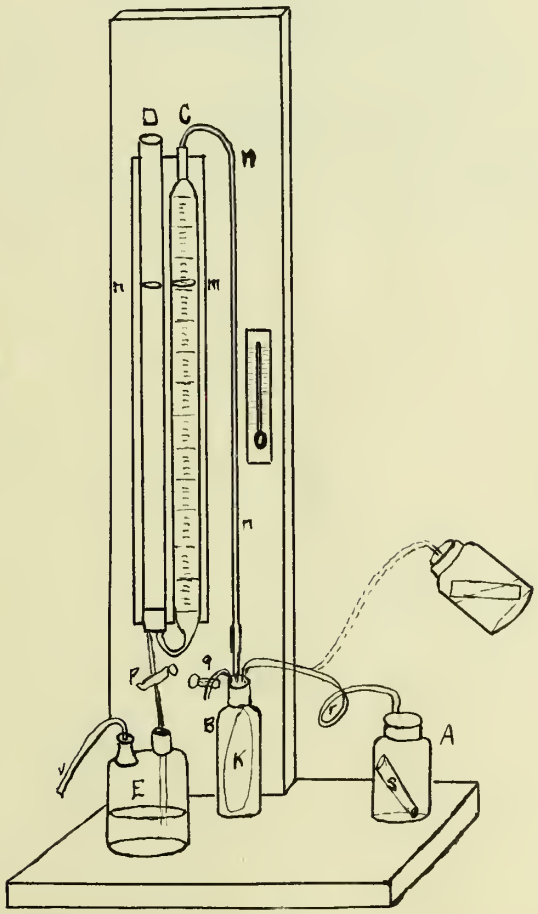


Fig. I

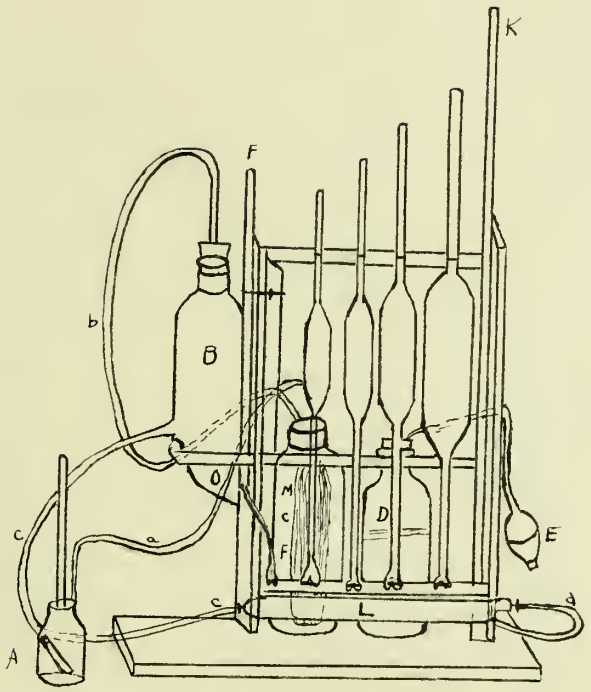


Figure II.

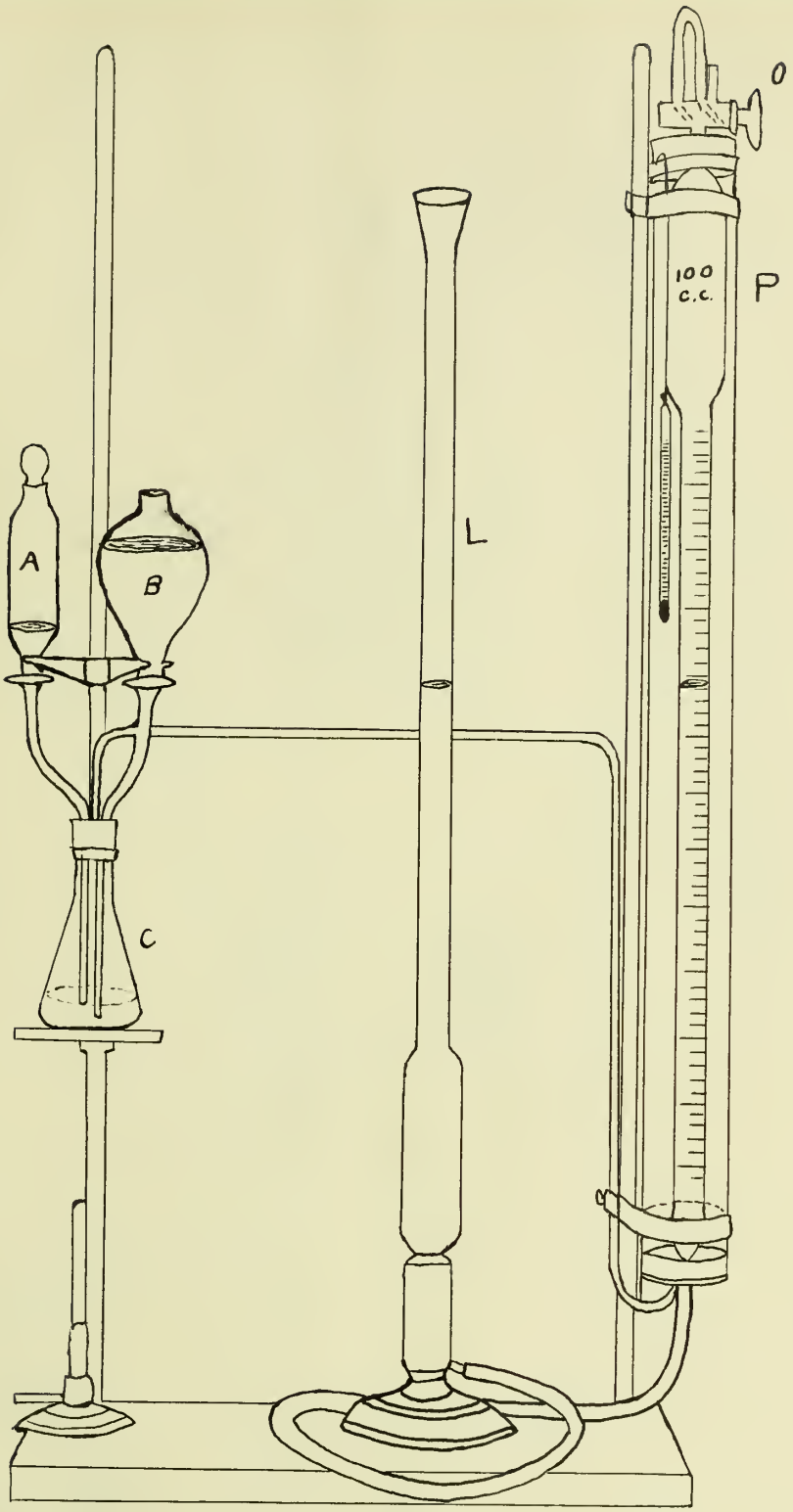


Figure III.

Table No. I

Results of Cast Iron.

| $Na_2O_2$ | Cast Fe | Mg. Powder | $KSO_4$ | Zn dust | Al. Powder | Ferro-Manganese | Tartaric Acid | Results and Discussion. |
|---|---|---|---|---|---|---|---|---|
| .5 grs. | .5 gr. | .5 gr | 1 gr. | — | — | — | — | Small amount of iron seemed to have been burned. |
| " | " | — | — | — | — | — | — | Bomb held over flame. No ignition. |
| " | " | .5 gr | — | — | — | — | — | No results |
| " | " | — | — | .5 & 1 gr. | — | — | — | " " |
| " | " | — | — | — | .5 & 1 gr. | — | — | " " |
| " | 1. gr. | — | — | — | — | — | — | " " |
| " | " | — | 1. gr $KSO_4$ | — | — | — | — | " " |
| " | " | — | — | — | — | — | .5 gr. | Small quantity of iron fused. |
| " | 2. gr. | — | — | — | — | — | " | Quantity increased in this case. |
| " | " | — | 1 gr. (Powder) | — | — | — | — | No ignition. |
| " | 3. gr | — | " | — | — | — | — | Good combustion. Same on repeating. |
| 10. gr. | " | — | 3 gr. | — | — | — | — | " " . Quiet fusion. Carbon o/o = 4.18 |
| " | " | — | 5 gr. | — | — | — | — | " " . Residue difficultly soluble. |
| " | 2 gr. | .5 gr. | " | — | — | — | — | " " |
| " | 1 gr. | " | 2 gr. | — | — | — | — | About ½ iron was burned and fused in this case. |
| 6.5 gr | " | — | " | Test Lead 1 gr. | — | — | — | No results. |
| 10 gr. | " | — | " | — | — | 1 gr. | — | Good combustion. Residue difficult to disintegrate. |
| " | " | — | 3 gr. | — | — | 2 gr. | — | " " . Quiet fusion. |
| " | 2 gr. | — | " | — | — | .5 gr. | — | " " " " |
| " | 1 & 2 gr | — | — | — | — | 1. gr. | — | No results in either case. |
| " | 2. gr | — | 2 gr. | — | — | " | — | " " |
| " | " | — | 3 gr. | — | — | " | — | Fair " . Slow fusion. |
| " | 1 gr. | — | — | — | — | — | .5 gr. | No " |
| 5 gr. | " | — | — | — | — | — | 1 gr | " " |
| " | " | — | — | — | — | — | 2 gr. | Violent action. Combustion fair. |

| $Na_2O_2$ | Cast Fe | Mg Powder ~~$KSO_4$~~ | $KSO_4$ | $NH_4SO_4$ | $PbO_2$ | S | | Results |
|---|---|---|---|---|---|---|---|---|
| 10gr. | 5grs. | — | 2gr. | — | — | — | — | Combustion very good. Most of iron burned. Residue almost insoluble. |
| 15gr. | " | — | " | — | — | — | — | No Results. |
| 10gr | 7gr. | .5gr | " | — | — | — | — | Fair " . Residue hard to disintegrate. |
| 5gr. | 1gr. | — | — | — | 1gr. | — | — | No Results. |
| 7gr | 2gr. | — | — | — | " | — | — | " |
| " | " | — | 1gr. | — | " | — | — | " |
| " | " | — | 2gr. | — | " | — | — | " |
| 10gr. | 3gr. | — | 3gr | — | " | — | — | Quiet action. Combustion good. Residue difficultly soluble. |
| " | " | — | — | 1.5gr. | " | — | — | Violent " . " " " " more soluble than above. |
| " | 2.5gr. | — | — | 1 gr | — | — | — | Reaction quiet " " . |
| " | " | — | — | " | — | — | — | " " " " Carbon = 3.72 o/o. |
| " | " | — | — | " | — | — | — | " " " " " = 3.66 " |
| " | " | — | — | " | — | 0.5gr. | — | Very good combustion. |
| " | Wrought iron 2.5gr | — | — | 1gr | — | — | — | Very little effect on iron. |
| " | " | — | — | .5gr | — | .5gr | | Combustion good. |

Results of Cast Iron

Table No. 1 Con.

# WEIGHT OF CARBON

## IN MILLIGRAMS PER CUBIC CENTIMETER OF $CO_2$

CALCULATED FROM .0019641 = WT. OF $CO_2$ AT 41° LATITUDE, PRESSURES CORRECTED FOR WATER VAPOR AND TEMPERATURE.

| t° \ mm | 720 | 722 | 724 | 726 | 728 | 730 | 732 | 734 | 736 | 738 | 740 | 742 | 744 | 746 | 748 | 750 | 752 | 754 | 756 | 758 | 760 | 762 | 764 | 766 | 768 | 770 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 4825 | 4839 | 4852 | 4866 | 4880 | 4893 | 4907 | 4920 | 4934 | 4948 | 4960 | 4974 | 4988 | 5001 | 5015 | 5028 | 5042 | 5055 | 5069 | 5083 | 5096 | 5110 | 5123 | 5137 | 5151 | 5164 |
| 11 | 4802 | 4816 | 4829 | 4843 | 4856 | 4870 | 4883 | 4897 | 4911 | 4924 | 4938 | 4951 | 4965 | 4978 | 4992 | 5005 | 5019 | 5032 | 5046 | 5059 | 5073 | 5087 | 5100 | 5114 | 5127 | 5141 |
| 12 | 4780 | 4794 | 4808 | 4821 | 4834 | 4848 | 4862 | 4875 | 4889 | 4902 | 4915 | 4929 | 4942 | 4956 | 4970 | 4983 | 4996 | 5010 | 5024 | 5036 | 5051 | 5064 | 5077 | 5091 | 5104 | 5117 |
| 13 | 4758 | 4772 | 4785 | 4799 | 4812 | 4826 | 4839 | 4853 | 4866 | 4880 | 4892 | 4906 | 4919 | 4933 | 4946 | 4960 | 4973 | 4987 | 5000 | 5013 | 5027 | 5040 | 5054 | 5067 | 5081 | 5094 |
| 14 | 4736 | 4749 | 4763 | 4776 | 4789 | 4803 | 4816 | 4830 | 4843 | 4856 | 4869 | 4883 | 4896 | 4909 | 4923 | 4936 | 4949 | 4963 | 4976 | 4990 | 5003 | 5017 | 5030 | 5043 | 5057 | 5070 |
| 15 | 4713 | 4727 | 4740 | 4753 | 4767 | 4780 | 4793 | 4807 | 4820 | 4833 | 4846 | 4859 | 4873 | 4886 | 4900 | 4913 | 4926 | 4940 | 4953 | 4966 | 4979 | 4992 | 5006 | 5019 | 5032 | 5046 |
| 16 | 4690 | 4704 | 4717 | 4730 | 4743 | 4757 | 4770 | 4783 | 4797 | 4810 | 4823 | 4837 | 4850 | 4863 | 4877 | 4890 | 4903 | 4916 | 4930 | 4943 | 4956 | 4969 | 4982 | 4996 | 5009 | 5022 |
| 17 | 4667 | 4681 | 4694 | 4707 | 4720 | 4734 | 4747 | 4760 | 4774 | 4787 | 4799 | 4813 | 4826 | 4839 | 4852 | 4866 | 4879 | 4892 | 4905 | 4919 | 4932 | 4945 | 4959 | 4972 | 4985 | 4998 |
| 18 | 4645 | 4658 | 4671 | 4684 | 4698 | 4711 | 4724 | 4737 | 4751 | 4764 | 4776 | 4789 | 4803 | 4816 | 4829 | 4842 | 4855 | 4869 | 4882 | 4895 | 4908 | 4922 | 4935 | 4948 | 4961 | 4975 |
| 19 | 4622 | 4635 | 4648 | 4661 | 4674 | 4687 | 4701 | 4714 | 4727 | 4740 | 4753 | 4766 | 4779 | 4792 | 4805 | 4819 | 4832 | 4845 | 4858 | 4871 | 4884 | 4897 | 4910 | 4923 | 4936 | 4950 |
| 20 | 4597 | 4610 | 4623 | 4637 | 4650 | 4663 | 4676 | 4689 | 4702 | 4715 | 4728 | 4742 | 4755 | 4768 | 4781 | 4794 | 4807 | 4820 | 4833 | 4847 | 4859 | 4872 | 4885 | 4899 | 4912 | 4925 |
| 21 | 4573 | 4586 | 4599 | 4612 | 4625 | 4638 | 4652 | 4665 | 4678 | 4691 | 4704 | 4717 | 4730 | 4743 | 4756 | 4769 | 4782 | 4796 | 4809 | 4822 | 4835 | 4848 | 4861 | 4874 | 4887 | 4900 |
| 22 | 4550 | 4563 | 4576 | 4589 | 4602 | 4616 | 4628 | 4642 | 4655 | 4668 | 4680 | 4693 | 4706 | 4719 | 4732 | 4745 | 4758 | 4771 | 4784 | 4797 | 4810 | 4823 | 4836 | 4849 | 4862 | 4875 |
| 23 | 4526 | 4539 | 4552 | 4565 | 4578 | 4591 | 4604 | 4617 | 4630 | 4643 | 4655 | 4668 | 4681 | 4694 | 4707 | 4720 | 4733 | 4746 | 4759 | 4772 | 4785 | 4798 | 4810 | 4823 | 4836 | 4850 |
| 24 | 4501 | 4514 | 4527 | 4540 | 4553 | 4566 | 4579 | 4591 | 4605 | 4618 | 4630 | 4643 | 4656 | 4669 | 4682 | 4695 | 4708 | 4721 | 4734 | 4747 | 4759 | 4772 | 4785 | 4798 | 4811 | 4824 |
| 25 | 4476 | 4489 | 4502 | 4515 | 4528 | 4541 | 4553 | 4566 | 4579 | 4592 | 4605 | 4618 | 4631 | 4644 | 4657 | 4670 | 4683 | 4695 | 4708 | 4721 | 4734 | 4746 | 4759 | 4772 | 4785 | 4798 |
| 26 | 4451 | 4464 | 4477 | 4490 | 4503 | 4516 | 4529 | 4541 | 4554 | 4567 | 4579 | 4592 | 4605 | 4618 | 4631 | 4644 | 4657 | 4670 | 4682 | 4695 | 4707 | 4720 | 4733 | 4746 | 4759 | 4772 |
| 27 | 4426 | 4439 | 4452 | 4465 | 4478 | 4490 | 4503 | 4516 | 4529 | 4542 | 4554 | 4567 | 4579 | 4592 | 4605 | 4618 | 4631 | 4644 | 4656 | 4669 | 4681 | 4694 | 4707 | 4720 | 4733 | 4746 |
| 28 | 4401 | 4414 | 4426 | 4439 | 4453 | 4465 | 4477 | 4490 | 4503 | 4516 | 4528 | 4541 | 4553 | 4566 | 4579 | 4592 | 4604 | 4617 | 4630 | 4643 | 4655 | 4668 | 4681 | 4693 | 4706 | 4719 |
| 29 | 4374 | 4387 | 4400 | 4413 | 4426 | 4438 | 4451 | 4464 | 4476 | 4489 | 4501 | 4514 | 4527 | 4540 | 4552 | 4565 | 4578 | 4590 | 4603 | 4616 | 4628 | 4641 | 4654 | 4666 | 4679 | 4692 |
| 30 | 4348 | 4361 | 4373 | 4386 | 4399 | 4412 | 4424 | 4437 | 4450 | 4462 | 4474 | 4487 | 4500 | 4512 | 4525 | 4538 | 4551 | 4563 | 4576 | 4589 | 4601 | 4613 | 4626 | 4639 | 4652 | 4664 |

Table No. II

Table No. III.

Carbon in Soils.

| Soil No. | Temp. | Bar. | Volume of $CO_2$ | Wt. in mg. of C per c.c. $CO_2$ | Total wt of C | $Na_2O_2$ factor | Wt. of C in Soil | o/o of C | o/o of C cal. to dry basis | Gravimetric o/o | Error | o/o Dry Matter |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 59 | 27°C. | 752 | 212.0 | .4631 | 98.177 | 31.36 | 66.817 | 3.3409 | 3.469 | 3.49 | +.021 | 96.291 |
| " | 27.0 | 742 | 207.4 | .4567 | 97.720 | " | 66.360 | 3.3180 | 3.446 | " | -.044 | " |
| " | 26.0 | 745 | 207.6 | .46115 | 95.735 | " | 64.375 | 3.2188 | 3.343 | " | -.146 | " |
| " | 26.0 | 745 | 210.4 | " | 97.026 | " | 65.666 | 3.2833 | 3.409 | " | -.040 | " |
| 119 | 23.0 | 739 | 201.4 | .46495 | 93.641 | " | 62.281 | 3.1140 | 3.199 | 3.24 | -.041 | 97.354 |
| " | 21.0 | 750 | 191.8 | .4769 | 91.47 | " | 60.110 | 3.0550 | 3.138 | " | -.102 | " |
| " | 21.0 | 756 | 188.8 | .4809 | 90.794 | " | 59.434 | 2.9717 | 3.052 | " | -.188 | " |
| 121 | 24.5 | 758 | 91.4 | .4734 | 43.270 | 28.74 | 14.530 | 0.7265 | 0.7586 | .68 | +.0786 | 95.763 |
| " | 23.0 | 760 | 89.0 | .4785 | 42.587 | " | 13.847 | 0.6929 | 0.7235 | " | +.0435 | " |
| 473 | 25.0 | 745 | 106.6 | .46375 | 49.440 | " | 20.700 | 1.035 | 1.0455 | .91 | +.1355 | 98.997 |
| " | 25.0 | 745 | 105.0 | " | 48.684 | " | 19.940 | 0.997 | 1.0071 | .91 | +.0971 | " |
| 474 | 25.0 | 751 | 73.0 | .46765 | 34.140 | " | 5.40 | 0.270 | 0.2768 | .37 | -.0932 | 97.521 |
| " | 26.0 | 751 | 74.4 | .46505 | 34.600 | " | 5.860 | 0.2980 | 0.3056 | " | -.0644 | " |
| " | 26.0 | 751 | 74.6 | " | 34.693 | " | 5.953 | 0.2970 | 0.3045 | " | -.0655 | " |
| 475 | 23.0 | 739 | 73.2 | .46495 | 34.134 | 31.36 | 2.774 | 0.1387 | 0.1432 | .13 | +.0132 | 97.534 |
| " | 24.0 | 747 | 73.6 | .46755 | 34.412 | 32.463 | 1.949 | 0.0975 | 0.0999 | " | -.0301 | " |
| 630 | 25.5 | 750 | 144.6 | .4657 | 67.340 | " | 38.600 | 1.9300 | 1.9874 | 1.94 | +.0474 | 97.112 |
| " | 22.0 | 750 | 142.5 | .4745 | 67.616 | " | 38.876 | 1.9438 | 2.0016 | " | +.0616 | " |
| 662 | 23.0 | 736 | 172.4 | .4630 | 79.821 | " | 51.081 | 2.554 | 2.6810 | 2.57 | +.1110 | 95.261 |
| " | 23.0 | 747 | 163.0 | .47005 | 75.618 | 29.6 | 46.018 | 2.3009 | 2.4153 | 2.57 | -.1547 | " |
| " | 23.0 | | | | | | | | | | | |
| 661 | 25.0 | 736 | 236.2 | .4579 | 108.156 | 28.74 | 79.416 | 3.9708 | 4.1806 | 4.15 | +.0306 | 94.98 |
| " | 23.0 | 736 | 226.2 | .4630 | 104.731 | " | 75.991 | 3.7995 | 4.0003 | " | -.0497 | " |
| 690 | 25.0 | 747 | 119.0 | .46505 | 55.341 | 29.6 | 25.741 | 1.2870 | 1.3110 | 1.31 | +.0010 | 98.168 |
| " | 24.0 | 748 | 116.8 | .4682 | 54.690 | " | 25.090 | 1.2545 | 1.2780 | " | -.0330 | " |

| Name of Coal used | Mixture | Vol. $CO_2$ | Temp. | Bar. | Wt. of C per c.c. $CO_2$ | Total wt. of C. | $Na_2O_2$ factor | Wt. of C in coal | o/o Carbon. |
|---|---|---|---|---|---|---|---|---|---|
| Danville (Pumptest | .5gr. coal 10 " $Na_2O_2$ | 182.4 | 24.0C | 749 | .46885 | 85.5182 mg. | 7.185 (¼ factor for 10grs. | 78.3332 | 62.664 Solution made up to 100 c.c. 25 c.c. used |
| " " | " | 182.2 | " | " | " | 85.4245 " | " " | 78.2395 | 62.592 " " |
| Buxton Coal | " | 189.0 | 25.0 | 747 | .46505 | 87.8945 " | 7.185 " | 80.7095 | 64.568 " " |
| " " | " | 190.0 | " | " | " | 88.3595 " | 7.185 " | 81.1745 | 64.940 " " |
| Odin Pea | " | 190.2 | 23.5 | 738 | .4631 | 88.0816 | 5.83 " | 82.2516 | 65.800 " " |
| " " | " | 191.6 | 24.0 | " | .4618 | 88.4809 | " " | 82.6509 | 66.124 " " |
| Para Lump | " | 215.6 | 25.0 | " | .4592 | 99.0035 | " " | 93.1735 | 74.540 " " |
| " " | " | 216.2 | 25.0 | " | " | 99.2790 | " " | 93.449 | 74.756 " " |
| Bloomington Coal | .25gr. Sulphur .3gr. Coal 1.5gr. $KSO_4$ 10gr. $Na_2O_2$ | 767.2 | 23.0 | 758 | .4772 | 366.1078 | 32.2695 | 333.8383 | 66.768 |
| " " | " | 769.0 | 22.5 | 756 | .47715 | 366.9284 | " | 334.6589 | 66.932 |
| " " | " | 767.4 | 22.0 | 756 | .4784 | 367.1242 | " | 334.8547 | 66.971 |
| " " | 1gr. $KSO_4$. .5 " Coal 10gr. $Na_2O_2$ | | | New Apparatus. | | | | | |
| " " | " | 769.4 | 24.5 | 756 | .47205 | 363.1953 | " | 330.9258 | 66.185 |
| Boiler Test (M.E. dept.) | " | 617.4 | 19.5 | 757 | .4852 | 299.5629 | 27.0063 | 272.5666 | 54.513 |
| Para Slack | .5gr. coal 10.3gr. $Na_2O_2$ 1.5gr. $KSO_4$ | 697.2 | 25.0 | 753 | .4689 | 326.9171 | 29.5766 | 297.3405 | 59.470 |
| " " | " " | 681.6 | 23.0 | 761 | .47915 | 326.5886 | 30.1509 | 296.4377 | 59.287 |
| " " | " " | 670.0 | 22.0 | 758 | .4797 | 321.3990 | 28.7152 | 292.6838 | 58.537 |
| " " | " " | 671.2 | 23.0 | 760 | .4785 | 321.16920 | " | 292.4540 | 58.491 |
| " " | " " | 677.2 | " | 758 | .4772 | 323.1598 | " | 294.4446 | 58.889 |
| " " | " " | 675.8 | " | " | .4772 | 322.4918 | " | 293.7766 | 58.755 |

Table No. IV. Coals.

Table No. 1

## Total Carbon in Illinois Coals det. by Vol. Method.

| Name | No. | Vol. $CO_2$ | Temp | Bar. | Wt. of C per c.c. of $CO_2$ | Total wt. of C | $Na_2O_2$ factor | Wt C. in coal | o/o of C | Difference |
|---|---|---|---|---|---|---|---|---|---|---|
| Sandoval Lump | 1 | 768.8 | 26.0 | 743 | .45985 | 353.5327 | 32.7027 | 320.8300 | 64.166 | |
| " " | 1 | 764.8 | 26.0 | 743 | " | 351.6933 | " | 318.9906 | 63.800 | .366 |
| Buxton " | 2 | 768.4 | 25.0 | 741 | .46115 | 354.1477 | " | 321.4450 | 64.290 | |
| " " | 2 | 758.0 | " | 750 | .4670 | 353.986 | " | 321.2833 | 64.257 | .033 |
| Danville " | 3 | 759.0 | 23.5 | 740 | .46425 | 352.3658 | 25.8005 | 326.5652 | 65.313 | |
| " " | 3 | 772.6 | 26.0 | 750 | .4644 | 358.8000 | 32.7027 | 326.0773 | 65.219 | .094 |
| Springfield " | 4 | 769.2 | " | 750 | " | 357.2200 | " | 324.5173 | 64.9034 | |
| " " | 4 | 756.4 | 24.0 | 740 | .4630 | 350.2132 | 25.8005 | 324.4127 | 64.8820 | .021 |
| Streator Slack | 5 | 738.0 | 26.0 | 750 | .4644 | 342.723 | 32.7027 | 310.0203 | 62.004 | |
| " " | 5 | 725.6 | 24.5 | 740 | .46175 | 335.0458 | 25.8005 | 309.2453 | 61.850 | .154 |
| " Lump | 6 | 812.6 | 25.5 | 750 | .4631 | 376.3200 | 32.7027 | 343.6173 | 68.7234 | |
| " " | 6 | 808.0 | 26.0 | " | .4644 | 375.2300 | " | 342.5273 | 68.5054 | .218 |
| Harrisburg " | 7 | 849.0 | 24.5 | " | .46825 | 397.5450 | " | 364.8423 | 72.9700 | |
| " " | 7 | 848.4 | " | " | " | 397.2640 | " | 364.5612 | 72.9120 | .060 |
| Streator Slack | 8 | 749.6 | 23.0 | 753 | .47395 | 355.2830 | 26.1626 | 329.1204 | 65.824 | |
| " " | 8 | 749.2 | 23.0 | " | " | 355.1000 | " | 328.8374 | 65.767 | .057 |
| " Lump | 9 | 810.2 | 22.0 | 740 | .4680 | 379.1736 | 25.8005 | 353.3731 | 70.675 | |
| " " | 9 | 800.0 | 23.5 | 753 | .4727 | 378.1640 | 26.1626 | 352.0014 | 70.400 | .275 |
| Centralia Slack | 10 | 651.6 | 23.0 | 756 | .4759 | 310.0964 | 26.8011 | 283.2953 | 56.66 | |
| " " | 10 | 656.4 | 23.5 | " | .47465 | 311.5603 | " | 284.7692 | 56.95 | .350 |
| " Lump | 11 | 720.8 | " | 753 | .4727 | 340.7230 | 26.1626 | 314.5604 | 62.912 | |
| " " | 11 | 719.6 | 23.5 | " | " | 340.1600 | " | 313.9974 | 62.799 | .113 |
| Bloomington Slack | 12 | 625.6 | 23.0 | " | .47395 | 296.5100 | " | 270.3474 | 54.0694 | |
| " " | 12 | 640.8 | 23.5 | 741 | .4649 | 297.9000 | " | 271.7374 | 54.3480 | .279 |
| " Lump | 13 | 739.0 | 23.0 | 740 | .4655 | 344.0045 | 25.8005 | 318.2040 | 63.6400 | |

Table No. V. (Cont.)

Total Carbon in Illinois Coals, det. by Volumetric Method.

| Name of Coal | No. | Vol. of $CO_2$ | Temp. | Bar. | Wt. of Carbon per c.c. $CO_2$ | Total wt. of Carbon | $Na_2O_2$ factor | Wt. of C. in sample | % of C. | Difference. |
|---|---|---|---|---|---|---|---|---|---|---|
| Bloomington Lump | 13 | 744.4 | 24.5 | 741 | .4624 | 344.2150 | 26.1626 | 318.0540 | 63.61 | .03 |
| " Slack | 14 | 717.6 | 25.0 | " | .46115 | 330.9230 | " | 304.7604 | 60.95 | |
| " " | 14 | 721.6 | " | " | " | 332.7770 | " | 306.6144 | 61.323 | .373 |
| " Lump | 15 | 821.4 | 25.5 | " | .45985 | 377.7200 | " | 351.5574 | 70.312 | |
| " " | 15 | 816.0 | 25.0 | " | .46115 | 376.3100 | " | 350.1474 | 70.030 | .082 |
| Trenton " | 16 | 655.6 | " | " | " | 302.3360 | " | 276.1731 | 55.234 | |
| " " | 16 | 654.0 | " | " | " | 301.7800 | " | 275.6174 | 55.323 | .089 |
| Fairbury " | 19 | 762.6 | 23.0 | 747 | .47005 | 358.4670 | " | 332.3044 | 66.461 | |
| T " " | 19 | 759.8 | " | " | " | 357.1500 | " | 330.9874 | 66.197 | .264 |
| Tilden " | 23 | 762.4 | 26.0 | 740 | .45790 | 349.1029 | 25.8005 | 323.3024 | 64.660 | |
| " " | 23 | 764.6 | 26.0 | " | " | 350.1103 | " | 324.3098 | 64.860 | .200 |
| Eldorado " | 25 | 816.8 | 27.5 | 741 | .45475 | 371.4417 | " | 345.6412 | 69.130 | |
| " " | 25 | 820.0 | 27.5 | " | " | 372.9000 | " | 347.0995 | 69.420 | .29 |
| Herrin Slack | 27 | 801.0 | 26.5 | 745 | .45985 | 368.3399 | 32.7027 | 335.6372 | 67.130 | |
| " " | 27 | 796.8 | 25.5 | " | .46245 | 368.4802 | " | 335.7775 | 67.160 | .03 |
| Assumption Lump | 35 | 733.0 | 24.0 | 751 | .47015 | 344.6166 | 27.8526 | 316.7640 | 63.3528 | |
| " " | 35 | 732.6 | " | " | " | 344.4484 | " | 316.5958 | 63.3191 | .033 |
| " Slack | 36 | 724.6 | 24.5 | " | .4689 | 339.7666 | " | 311.9140 | 62.3828 | |
| " " | 36 | 711.4 | 20.5 | 746 | .47555 | 338.3062 | " | 310.4536 | 62.0907 | .2921 |
| Danville Lump | 46 | 793.4 | 25.0 | 736 | .45790 | 363.2979 | 28.3700 | 334.9279 | 66.9856 | |
| " " | 46 | 794.6 | " | " | " | 363.8473 | " | 334.4773 | 66.8955 | .09 |
| Kangley " | 48 | 777.4 | 24.5 | " | .45920 | 356.9821 | " | 328.6121 | 65.7224 | |
| " " | 48 | 776.8 | 24.0 | 738 | .46180 | 358.7262 | " | 330.3562 | 66.0712 | .35 |
| " Slack | 49 | 642.2 | 23.5 | " | .46305 | 297.3707 | " | 269.0007 | 53.8000 | |
| " " | 49 | 648.0 | 24.0 | " | .46180 | 299.2464 | " | 270.8764 | 54.1750 | .37 |

# Miscellaneous Results.

Table No. VI.

| Substance | Mixture | Vol. of $CO_2$ | Temp °C. | Bar. mm | Wt. of Carbon per c.c. $CO_2$ mg. | Total wt. of C. | $Na_2O_2$ factor | Wt. C in sample | % C in sample |
|---|---|---|---|---|---|---|---|---|---|
| Cane Sugar | .75 gr. sugar 1 gr. $KSO_4$ 10 gr. $Na_2O_2$ | 688.2 | 22.5 | 748 | 47195 | 324.7960 | 32.2695 | 292.5265 | 39.003 |
| " " | " " | 666.0 | 20.0 | 749 | 47875 | 318.8475 | " | 286.5780 | 38.201 |
| $Na_2CO_3$ Solution | 1 gr. $Na_2CO_3$ in water | 230.2 | 23.5 | 752 | 4720 | 108.6544 | — | 108.6544 | 10.865 |
| " " | " " | 235.6 | 25.5 | 752 | 4669 | — | — | 110.0016 | 11.000 |
| " " | 1.5 gr. $Na_2CO_3$ | 358.0 | 26.0 | 753 | 46635 | — | — | 166.9433 | 11.130 |
| Calcite crystal | 1 gr. | 240.6 | 22.0 | 758 | 4797 | — | — | 115.4158 | 11.541 |
| " " | " | 246.4 | 26.5 | 756 | 4669 | — | — | 115.0443 | 11.504 |
| Oxalic acid | 4 gr. oxalic acid 2 gr. $KSO_4$ 10 gr. $Na_2O_2$ | 216.8 | 21.0 | 746 | 4743 | 102.8282 | 27.0063 | 75.8219 | 18.955 |
| " " | " | 213.8 | 20.0 | 748 | 4781 | 102.2178 | 30.2500 | 71.9678 | 17.992 |
| Tartaric acid | .5 gr. acid 1 gr. $KSO_4$ 10 gr. $Na_2O_2$ | 398.4 | 23.0 | 756 | 4759 | 189.5986 | 32.2695 | 157.3291 | 31.466 |
| " " | .75 gr. Sample 1 gr. $KSO_4$ 10 gr. $Na_2O_2$ | 541.9 | 22.0 | 750 | 4745 | 257.1316 | " | 224.8621 | 29.981 |
| " " | 4 gr. sample 2 gr. $KSO_4$ 10 grs. $Na_2O_2$ | 322.0 | 21.5 | 748 | 4744 | 152.7568 | 27.0063 | 125.7505 | 31.440 |
| " " | " | 318.4 | 20.0 | " | 4781 | 152.2270 | " | 125.2207 | 31.305 |
| Gillsonite | .3 gr. sample 1.5 gr. $KSO_4$ 10.8 gr. $Na_2O_2$ | 596.3 | 20.5 | 736 | 4690 | 279.6637 | 33.1340 | 246. | 82.176 |
| Lignite (Mississippi) | .2 gr $KClO_3$ .8 " $KNO_3$ .5 " Sample 10 " $Na_2O_2$ | 526.6 | 21.5 | 749 | 47505 | 250.1613 | 27.292 | 222.8693 | 44.574 |
| " " | " | 525.4 | 22.0 | 749 | 47385 | 248.9610 | " | 221.6690 | 44.334 |
| " (North Dakota | " | 680.2 | 25.5 | 745 | 46245 | 314.5585 | 24.6332 | 289.9253 | 57.985 |
| " " | " | 677.0 | " | " | " | 313.0787 | " | 288.4455 | 57.690 |
| Gasoline (Richards & Weeks Thesis M.E. Dept. U. of I | .2540 gr. Sample 1 gr $KSO_4$ .5 " $NH_4SO_4$ 10 " $Na_2O_2$ | 465.8 | 21.5 | 743 | 47115 | 219.4600 | 22.5000 | 196.9600 | 77.540 |

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